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THE IMPACT OF ANIMATION TIMING AND LOCATION ON VISUAL SEARCH TASK PERFORMANCE IN THE WEB ENVIRONMENT

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Abstract

Research results from a previous study show that animation as non-primary information significantly reduces information-seeking performance in a web-based environment (Zhang 2000). This study continues to explore the impact of animation timing and location on visual search tasks. The results indicate that (1) animation that appears during the middle or toward the end of an information-seeking task degrades performance more significantly than animation that appears at the very beginning. (2) Animation that appears and disappears repeatedly affects performance much more than animation that appears on the screen all the time. And (3) animation on the left side of the screen affects performance more than animation on the right side. This study helps understand the impact of animation use in the web environment, thus has practical implications for website designers as well as online advertisers in the design of effective webpages using animation.

Keywords: Human-web interface, visual attention, animation, and experimental study

Introduction

Animation is a dynamic visual statement, form, and structure evolving through movement over time (Baecker & Small 90, p251). With the rapid advancement of software tools such as JAVA, VRML, and specialized graphic and animation packages, animation becomes both easy to produce and widely used, especially in the web environment by webpage designers and online advertisers. A recent study revealed that animation as a non-primary information stimulus in the web environment (most online ads are this type of animation) affects user's information seeking performance (Zhang 2000). Using visual attention theories, Zhang formally evaluated the impact of animation on an individual's information searching performance (errors and time) in a lab-controlled experiment. Visual search tasks were used in the study where subjects were instructed to count, as quickly and accurately as possible, how many times a target string appeared in a table. Animations were in several position locations outside the table, and appeared and disappeared repeatedly with pre-defined duration during a task. Performance was based on the speed and accuracy. The study showed that (1) animation as a non-primary stimulus deteriorates viewer information seeking performance. (2) As the difficulty of the task (Lavie & Tsal 1994, Lavie 1995) increases, viewer performance is less affected by animation. (3) Animation that is similar in content but irrelevant to a task has more negative impact than animation that is dissimilar to the task. (4) Animation that is brightly colored has a stronger negative effect on viewer performance than dull colored animation.

This research continues to examine the impact of the timing of animation onset and the location of animation on user information seeking performance. Animation in this study is a non-primary stimulus that carries no information for the information seeking tasks. To eliminate unnecessary sources of variances, the study was set up as a lab-controlled experiment where certain factors were eliminated or controlled.

The practical goal of this research is to provide webpage designers with evidence rather than speculation on whether and how to use animation in webpages. As many more people need to search for information on the web, and encounter animation more frequently, research that investigates the actual effect of animation becomes increasingly important.

Research Hypotheses

Studies on stimulus onset asynchrony, or SOA (e.g. Yantis & Jonides 1990, Mayor & Gonzales-Marques 1994) report that abrupt visual onsets do not necessarily capture attention in violation of an observer's intention. Interference is dependent on whether a subject's attention is pre-allocated to the focused task before a distractor appears. This means that a subject's attempts can prevent a process from proceeding. In a stimulus onset asynchrony study, Yantis & Jonides (1990, Experiment 2) found that focusing attention in response to a valid and temporally useful cue (-200ms) virtually eliminated any effect of abrupt onset in the discrimination task. When the attentional cue was not available in advance of the onset of the test (0ms and 200ms), attentional resources could not be focused in anticipation of the critical item. Under these circumstances, abrupt onset had a substantial influence on reaction time.

There are two cautions for applying existing SOA results to this study directly. First, the exposure duration in existing studies for all cues was in ms (e.g. -200 ms, -100ms, and 200 ms). In this study, subjects are exposed to stimuli that last in seconds. Whether one can expect similar results remains to be tested. Second, existing studies in stimulus onset asynchrony do not focus on the rest of the exposure after a distractor is introduced. They did not consider the change of attention patterns over exposure time.

Nevertheless, the researcher considers pre-allocating a subject's attention to information seeking tasks by introducing animation in the middle and toward the end of the tasks. Animation onset at the beginning of the task is also considered for comparison purpose.

Hypothesis 1. Animation that appears at the same time as the task does has larger negative effect than animation that appears in the middle of the task, which in turn has a more negative effect than animation that appears toward the end of the task.

A related issue to applying SOA in a web-based computing environment is the duration of animation during a task. Animation can stay on once it is on. The same animation can also appear and disappear repeatedly (on-off-on) during the task. Since the on-off-on animation can be regarded as many abrupt onsets, the performance may be affected by every onset. Thus, we expect that:

Hypothesis 2. Animation that stays on during the task affects task performance less than animation that appears and disappears repeatedly.

Animation can be placed at any possible position on a screen. Putting animation (or an online ad) at the top may have a similar effect as animation that appears at the same time that the task starts. It could also be regarded as a no animation condition if viewers scroll down the page to "get rid of" it. It is uncertain, however, whether the animation on the left side of the screen would have a similar effect as the animation on the right side of the screen. We as human beings are trained to read from left to right, so are most of the times information is presented on the screen. Our eyes search for the start of a line but don't always look for the end of a line (we often scan or skim it over). If we consider reading one line as a smaller task, then animation on the left would be similar to animation appearing at the beginning of a task, and animation on the right is similar to animation appearing toward the end of the task. In addition, our eyes spend a relatively longer time to "find" the beginning of a line. That is, attention is more demanding when one is looking at the left side than when the right side. Animation on the left side thus may be exposed longer and have a stronger negative effect than animation on the right side.

Hypothesis 3. Animation on the left side of the screen has a stronger negative effect on tasks than animation on the right side of the screen.

Experiment Design

This study used a within-subject factorial 2x4 design. The first independent variable was the location or side of the animation on the screen, left or right. The second independent variable was the stage at which animation appears. Stage 1 was the beginning of the task, stage 2 the middle, stage 3 the last quarter of the task, and stage 4 the on-off-on starting at the beginning of the task. A no animation condition was considered as a baseline condition. Table 1 lays out the structure of the design. Each subject does a total of nine tasks (2x4 plus baseline).

Table 1. Structure of the Study

Task ID	Stage 1	Stage 2	Stage 3	On-off-on	Baseline
Left	1	2	3	4	0
Right	5	6	7	8	

In order to make the information-seeking tasks closer to reality and eliminate the effect of subjects' pre-knowledge of information content on the potential outcome, words were used to form a nonsense paragraph. A target word (string of letters) could appear many times in the paragraph. A subject's task was to click all appearances of only the target word. A paragraph template determined the number of total display items, number of targets, and the exact location of each target. In order to make it possible to compare the performance change over time under different conditions, and to minimize the potential learning effect of target locations, a template was varied slightly on target locations in different conditions. For example, given the locations of targets in the baseline, stage 1 could be one position off with left-right order, and stage 2 had one position off with right-left order. There were a total of three templates. Table 2 depicts this variation. Each task corresponded to one of the three templates. Order or learning effect was reduced, if not eliminated, by randomly ordering all the nine tasks for each subject.

Table 2. Target Item Distribution in Same Paragraph under Different Conditions

Template 1 (for baseline)	Template 2 (left-right, one position off)	Template 3 (right-left, one position off)
<pre> _ _ _ _ _ x _ _ _ _ _ x _ _ _ _ _ x _ _ _ _ _ _ _ x _ _ _ _ _ _ _ _ _ _ x _ _ _ _ _ x _ _ _ _ _ _ _ _ _ _ x _ _ _ _ _ _ _ _ _ _ x _ _ _ _ _ _ _ _ _ _ x _ _ _ _ _ x _ _ _ _ _ </pre>	<pre> _ _ _ _ _ o _ _ _ _ _ o _ _ _ _ _ o _ _ _ _ _ _ _ _ _ _ o _ _ _ _ _ o _ _ _ _ _ o _ _ _ _ _ _ _ _ _ _ o _ _ _ _ _ _ _ _ _ _ o _ _ _ _ _ _ _ _ _ _ o _ _ _ _ _ o _ _ _ _ _ </pre>	<pre> _ _ _ _ _ f _ f _ _ _ _ _ f _ _ _ _ _ _ f _ _ _ _ _ _ _ _ _ _ f _ _ _ _ _ f _ _ _ _ _ _ _ _ _ _ f _ _ _ _ _ _ _ _ _ _ f _ _ _ _ _ _ _ _ _ _ f _ _ _ _ _ f _ _ _ _ _ </pre>

Animations in this study had the following characteristics: bright color, fixed size of 200x200 pixels, moderate speed, fixed distance from the paragraph, and neutral images that had little to do with the content of the tasks. Example animations used were animals, objects such as airplane and balls, and human faces.

There were three webpages associated with each of the nine tasks: pre-page, task-page, and post-page. A pre-page displayed the target that a subject was to look for in the task-page. A post-page gave an indication of task completion and a link leading to the next task. A task-page, with or without animation depending on the condition, had a nonsense paragraph with the target word appearing many times in positions determined by a template. Each word (target or non-target) in the paragraph was clickable and did not change color after being clicked. The webpage flashed after each click. Subjects were thus suggested to develop a strategy that would help memorize their current position in a task-page.

The subjects were 25 volunteer graduate students enrolled in a northeastern university in the United States, majoring in Information Studies, Linguistics, and Computer Engineering. The average age was 30.5 (std. = 6.7). They spent an average of 19.4 hours (std.=7.7) on the Web per week. None of them reported being colorblind. Five prizes were designed to encourage best performance. One first-prize (\$40) was for the best performer; four second-prizes (\$15 each) were for the next four best performers. Subjects were told that they should complete each task-page as accurately and quickly as possible. They practiced with two tasks (not used in the competition) to familiarize themselves with the exercise before the competition started. Each subject then did a total of nine tasks, followed by a questionnaire that collected data on demographic background, interference perception, and attitude toward animation. When everyone completed the questionnaire, the performance scores were calculated, best performers identified, and awards given. The session lasted less than fifty minutes. The computers used for the study were Dell Pentium II with 17-inch Trinitron monitors, all were connected by a campus wide LAN. The web browser was Netscape Navigator 4.51. A computer server captured the time (the exact click on each word in the task-page, and the moment a subject entered a task-page and the moment s/he finished) and accuracy data.

Data Analysis and Results

Subjects were told to complete each task as accurately and quickly as possible. They were aware that they could sacrifice one factor (e.g. accuracy) to achieve the other (e.g. time). Thus simply considering one of the two variables may not reveal the true

phenomenon of animation impact. Here performance scores, which is determined by the click accuracy and amount of time spent on the task-page, were used for the data analysis.

Different tasks may have a difference number of targets. Subjects were encouraged to emphasize on clicking all the targets and were told that the number of clicked targets was weighted by being counted repeatedly (as the square value). They were also told that the number of wrong clicks would affect the accuracy of a task too. The following formula, where click accuracy is dependent on the number of correctly clicked targets, the number of wrong clicks, and the total number of targets, was thus used to calculate the click accuracy of a task: $CA = \text{NumberOfClickedTargets} * \text{NumberOfClickedTargets} / (\text{NumberOfTargets} + \text{NumberOfWrongClicks})$. Performance scores were calculated by the formula: $P = 10000 * CA / \text{TimeOnTaskpage}$, where the constant 10000 is to eliminate the decimal places of the p-scores.

A paired t-test was conducted to compare the baseline performance scores to each of the eight animation performance scores. Table 3 is the t-test results showing a significant difference between the baseline and any animation condition ($\alpha = .05$). This confirmed what Zhang (2000) has found out that animation as non-primary information significantly reduces information-seeking performance in a web-based environment.

Table 3. Paired t-test for Performance Means between Naseline and Any Animation Task (df=24)

	(t0 t1)	(t0 t2)	(t0 t3)	(t0 t4)	(t0 t5)	(t0 t6)	(t0 t7)	(t0 t8)
Paired t-stat	3.2688	5.1907	3.9687	4.5776	1.9524	3.9184	3.3287	4.3804
p (one-tail)	0.0016	0.0000	0.0003	0.0000	0.0313	0.0003	0.0014	0.0001

A 2x4 full factorial ANOVA for within subject repeated measures on SIDE (left and right) and STAGE (beginning, halfway, last quarter, and on-off-on) was conducted. Table 4 is the ANOVA results. Both SIDE and STAGE have significant main effects (with high statistical powers). No significant interaction effects are shown.

Table 4. Tests of Within-Subjects Effects on Performance

Source	df	F	Sig.	Observed Power ($\alpha = .05$)
SIDE	1	13.463	.001	.940
STAGE	3	17.727	.000	.994
SIDE * STAGE	3	.861	.476	.054

Pairwise comparisons on STAGE condition (Table 5) indicate that subjects performed the task more effectively in the Stage 1 condition than that of Stages 2, which is worse than that of Stage 3. Hypothesis 1 states that "Animation that appears at the same time as the task does (Stage 1) has larger negative effect than animation that appears in the middle of the task (Stage 2), which in turn has a more negative effect than animation that appears toward the end of the task (Stage 3)." The first part of this hypothesis is not supported by the results (Stage 1 has a better performance than Stage 2), while the second part is (Stage 2 has a worse performance than Stage 3).

Table 5. Pairwise Comparisons of Performance of STAGE, On-off-on, and Baseline

(I) STAGE	(J) STAGE	Mean Difference (I-J)	Std. Error	Sig.
Stage1	Stage2	308.300	50.667	.000
	Stage3	135.900	60.362	.034
	On-off-on	338.180	59.257	.000
Stage2	Stage3	-172.400	44.464	.001
	On-off-on	29.880	62.273	.636
Stage3	On-off-on	202.280	73.658	.011

Table 5 also reveals that the on-off-on condition has a significantly worse performance score than all other stage conditions except Stage 2 where the difference is not significant. This confirms Hypothesis 4 in most part, which states "Animation that stays on all the time during the task affects task performance less than animation that appears and disappears repeatedly."

A detailed pairwise comparison on SIDE (Table 6) shows that the mean difference of performance scores between LEFT and RIGHT side is significantly negative indicating that performance is worse when animation is on the left side than on the right side, which is what hypothesis 3 suggested.

Table 6. Pairwise Comparison of Performance on SIDE

(I)SIDE	(J)SIDE	Mean Difference (I-J)	Std. Error	Sig. ($\alpha = .05$)
LEFT	RIGHT	-179.650	48.962	.001

Conclusion

This study confirmed what Zhang (2000) has discovered in general: animation decreases information-seeking performance. The data did not support hypothesis 1 completely. Animation, when it appeared in the middle or toward the end of the task, had larger negative impact than animation that appeared at the beginning of the task. This was surprising initially to the researcher. A further analysis on some questionnaire comments revealed that subjects were not expecting to see animation once they started a task without animation at the beginning. Thus animation popping up in the middle of the task turned out to be a surprise. This may help explain the Stage 3 condition where performance is also worse than the Stage 1 and the baseline conditions.

Hypothesis 2 about the stability of animation is confirmed for the most part. Repeated onset of animation caused subjects' performance to severely decrease. An interesting fact, though, is that the on-off-on animation caused about the same damage to one's performance as the animation that appeared halfway and stayed until the end of the task. Although there was no hypothesis to compare these two treatments, one would think intuitively that the on-off-on condition would have a much worse effect than the halfway condition. Hypothesis 3 is supported that animation on the left side has a bigger negative impact than animation on the right side of the screen.

In general, subjects were not able to block the animation's effect. Not being able to block animation's effect, even though they attempted to ignore it and believed they did, means that animation is processed to some extent involuntarily, according to several visual attention studies. For example, many researchers (e.g. Allport 1989, Miller 1991, Yantis & Jonides 1990, Duncan 1984) have argued that even though the processing of unattended stimuli can be attenuated with certain manipulations, it cannot be totally ruled out. The meaning of the unattended stimulus must be processed to some extent. Because our attention has a limited capacity, the available resources for attending the pertinent information is reduced, and thus information processing performance, including speed and accuracy, deteriorates (Miller 1991, Treisman 1991, Warder & Brown 1944, Driver & Baylis 1989).

This study presents empirical evidence of animation's effect under different timing and location conditions. This type of empirical evidence is scant and is very much needed for guiding current webpage designs to be more effective, efficient, and human oriented. With the number of Internet users increases dramatically, webpages with animation and online ads affect millions of people who seek information on the Web, and millions of people who may benefit from online ads.

This study suggests strategies for both website content providers and online advertisers, showing a dichotomy between the very different goals. Content providers want to make money from advertising but also need to care about potential side effects of ads on their viewers' information seeking performance. Given a choice, content providers could prefer ads that have minimum distracting effects. Results from this study suggest that putting ads earlier on the page and on the right side should help reduce negative effects.

On the other hand, online advertisers or marketers want to continue grabbing viewers' attention knowing that the ads would be processed, to some extent, involuntarily. Thus they would negotiate with content providers to put ads where viewers would be most affected, such as the left side of the screen. They could also benefit from the timing strategy suggested by this study, where ads should be put, for example, in the middle of the content. If possible, they might want to negotiate to have the ads repeatedly appear and disappear on the screen.

In order to eliminate the potential sources of variances and be able to test the hypotheses, this study used a lab-controlled experiment where students were the subjects and many factors were simplified or eliminated. It thus has the typical limitations of this type of experiments. This includes the tasks that are designed to mimic rather than to be the real tasks in the web environment. Subjects were not a true representation of web users. And animations were controlled in terms of size, color, speed/movement, content, and location on the screen.

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